Nested biophysical modeling of the Coastal Gulf of Alaska: inferences from circulation results

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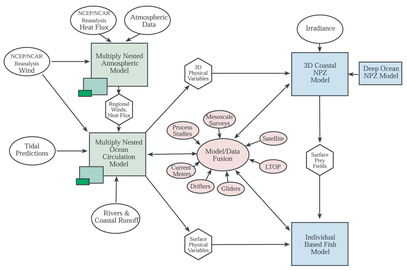
ABSTRACT

As part of Northeast Pacific GLOBEC, we have constructed (and continue to refine) a set of nested physical and biological models of coastal dynamics, designed to include basin-scale (North Pacific [Npac, 40-km resolution]) regional (Northeast Pacific and Bering Sea [NEP, 10-km resolution]) and local (Coastal Gulf of Alaska [CGOA, 3-km resolution]) influences on coastal transport, and their subsequent impact on lower trophic level dynamics (and ultimately salmon life histories). All are nested in one-way mode, with each finer-scale domain receiving its boundary conditions from a larger-scale model. Recent simulations include passive Lagrangian float tracking. Following a brief overview of our nested approach, we examine several aspects of the circulation fields derived thus far. Eulerian characterstics of the upwelling and downwelling regions in the regional (NEP) model are examined via EOF analysis; monthly timeseries of the dominant spatial modes of SST and SSH are compared with monthly climate indices such as the PDO and ENSO. A significant correlation of modeled coastal SSH with ENSO is observed, even without NPac -derived boundary conditions (that is, the correlation is observed even with purely local wind forcing). Eulerian currents and salinity fields from the CGOA model exhibit statistical features observed at LTOP moorings; specifically a 5-6 day periodicity in the fall, which may be due to advection of baroclinic instabilities. Lagrangian histories of depth, temperature and salinity in the CGOA are examined, as a function of release time, release location and depth; the resulting tracks suggest spatial pathways of nutrients, plankton, and juvenile fish in different seasons.

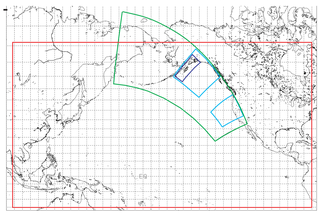
BACKGROUND

As part of the Northeast Pacific GLOBEC program, we are constructing a set of nested physical and biological models of coastal dynamics.



DOMAINS OF NESTED CIRCULATION MODELS

Basin scale North Pacific (NPac) (40-km)
Regional scale Baja CA to Bering Sea (NEP) (10-km)
Local scale Coastal Gulf of Alaska (CGOA) (3-km)
Local scale Coastal California (CC) (3-km)

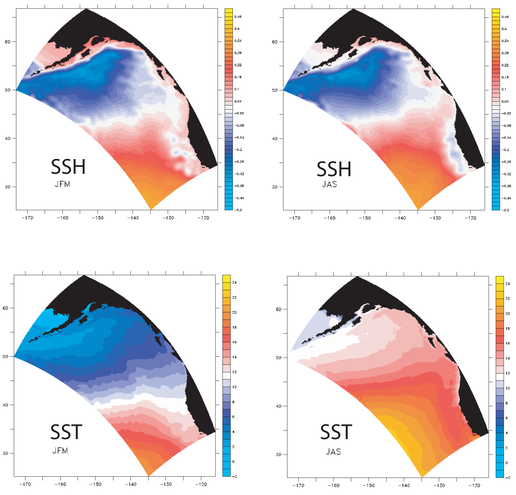


MODEL STRUCTURE AND FORCING

* NEP model with no nesting
* Regional Ocean Modeling System (ROMS)
* Primitive Equation physics with LMD mixing
* Daily surface heat and winds from NCEP reanalyses
* Boundary conditions from Levitus climatology
* 5 years of NEP hindcasts (1997-2001)

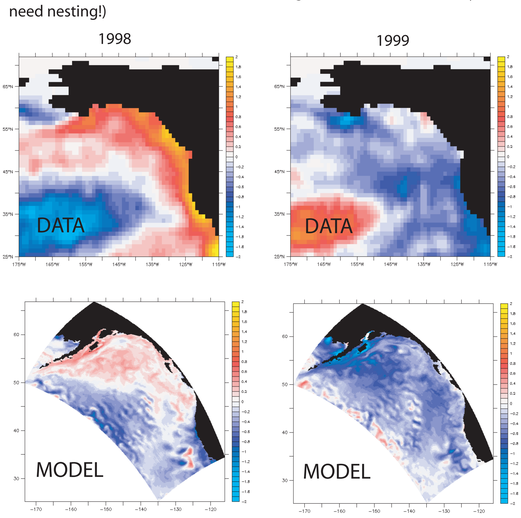
SEASONAL MEANS

Mean winter and summer patterns from NEP model output



INTERANNUAL VARIABILITY OF SST

* Subtract mean monthly values from model (NEP) and data (Reynolds)
* Look at winter (JFM) 1998 vs. 1999 perturbation SST
* Model SST conforms to Reynolds SST near Alaska but is weak off California - underscores need for El Nino signal at southern boundary (i.e. need nesting!)



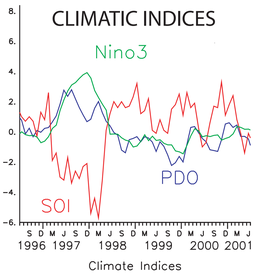
EOF ANALYSIS

* Average model results in time (monthly)
* Average model results in space (100-km bins)
* Calculate EOF spatial modes and time series
* Project full grid onto resulting modes
* Compare time series with SOI, PDO and NINO3

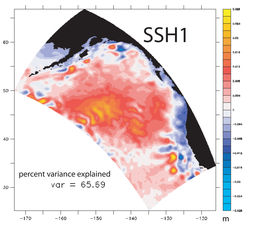
SSH timeseries correlation

	SOI	PDO	NINO3
1	0.1446	-0.0469	-0.1961
2	0.2237	-0.3665	-0.2564
3	0.1921	-0.5150	-0.3491

CLIMATIC INDICES

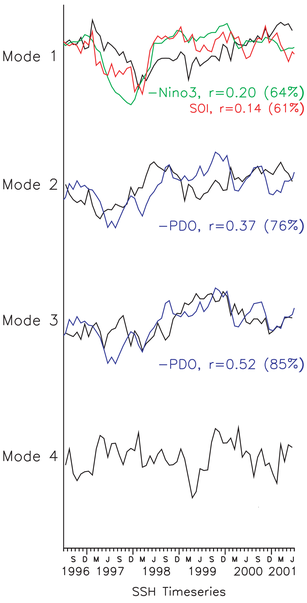


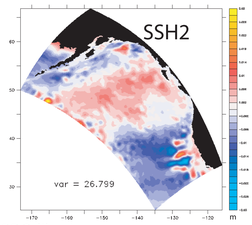
SSH SPATIAL MODES



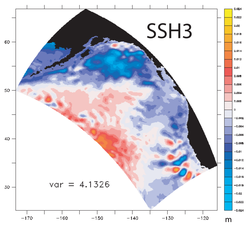
ENSO-like time pattern
big part of total perturbation signal

SSH EOF TIMESERIES





PDO-like time pattern
intensification/northward shift of gyres

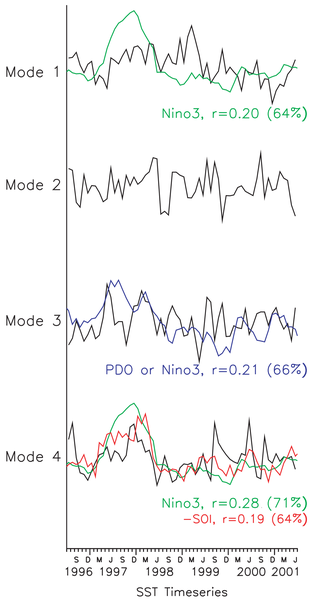


PDO-like time pattern
covariant strengthening/weakening of both gyres

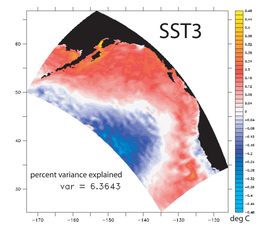
SST timeseries correlation

	SOI	PDO	NINO3
1	-0.0981	0.0776	0.1962
2	-0.0546	0.1294	0.1228
3	-0.1542	0.2153	0.2126
4	-0.1945	0.1329	0.2837

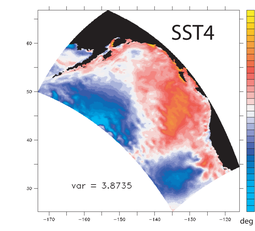
SST EOF TIMESERIES



SST SPATIAL MODES



PDO/ENSO-like time patterns
PDO-like spatial patterns
Warming near coast/cooling in basin
Small part of total signal



SUMMARY and CONCLUSIONS

For this *locally forced* circulation model without nesting:
* ENSO-related interannual variability appears mainly in the SSH signal
* Possible PDO-related gyre variations (but need longer series to test)
* Enhanced downwelling all along the coastline during ENSO
* Weaker (but significant) correlations found with SST
* Strong correlations with ENSO found in EOFs of SSS (not shown)
* Similar results obtained with EOF analysis of coastal areas only (not shown)

A BIOLOGICAL HYPOTHESIS

* Enhanced downwelling (reduced upwelling) will substantially modify cross-shelf transport in these downwelling (Coastal Gulf of Alaska; CGOA) and upwelling (Coastal California: CC) regions. While this will *reduce* the nutrient supply to coastal ecosystems of the CC, it could simultaneously *enhance* nutrient supply to the CGOA due to high surface nutrient levels in the subarctic gyre. Could this account for part of the observed covariance in productivity of the two regions?

NEXT STEPS

* Discrepancies with SST in the California region underscore the need for nested models
* Longer runs needed to obtain robust statistics (e.g. need multiple realizations of ENSO)
* Compare with other climate indices
* Perform parallel EOF analysis on data (e.g. Reynolds SST, altimeter SSH for this region)

For additional information see http://www.pmel.noaa.gov/~dobbins/nep.html